5/4/94

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

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MEMORANDUM

OFFICE OF
PREVENTION, PESTICIDES AND
TOXIC SUBSTANCES

SUBJECT: Linuron RED

FROM: Anthony F. Maciorowski
Ecological Effects Branch/EFED

Douglas D. Urban 5/4/94

TO: William Schneider
SACS/EFED

Enclosed are the following:

1. EEB's chapter for Linuron

2. Data Requirement Table

The following are the Levels of Concern (LOC) that are exceeded in this analysis:

1. The avian restricted use LOC is exceeded on short grass at the 3 and 4 lb ai/A rates. Avian endangered species and chronic LOCs are exceeded for all the rates evaluated.

2. Mammalian high acute, restricted use, endangered species, and chronic LOCs are exceeded for all the rates evaluated.

3. The fish restricted use and endangered species LOCs are exceeded with the rights-of-way (ROW) use, based on runoff to a wetland area. Direct application to a wetland area would exceed all LOCs. The 4 lb ai/A crop rate with pond model exceeds the endangered species LOC. Fish chronic effects cannot be fully evaluated since a NOEL was not determined. Known effect levels would be exceeded for the ROW use and the 4 lb ai/A crop rate.

4. The aquatic invertebrate high risk, restricted use, and endangered species LOCs are exceeded for ROWs (based on either runoff or direct application to wetlands). The restricted use and endangered species LOCs are exceeded at all other sites and rates evaluated (pond model). Chronic effects cannot be evaluated at this time due to inconsistencies between acute and chronic testing.

5. A terrestrial plant risk assessment cannot be done due to the lack of adequate data. High risk is likely, based on the the herbicidal properties of linuron. High risk and endangered plant LOCs are exceeded for aquatic plants with the ROW use, based on the one available EC50. When the data base is complete, further uses may exceed LOCs.

The "value added" of all the data requirements specified in the EEB chapter and data requirement table is considered "high" by EEB, except for the avian LC50 with TGAI, which is considered "low" (H. Craven, pers. comm.).

If you have any questions please contact Harry Craven (305-5320) or James Felkel (305-5828).

ECOLOGICAL EFFECTS BRANCH
SCIENCE CHAPTER FOR
REREGISTRATION ELIGIBILITY DOCUMENT
FOR LINURON

A. ECOLOGICAL HAZARD

1. Topical Summaries

A. Effects to Non-Target Birds

Six studies in four citations have been evaluated by EEB under this topic. All studies were considered acceptable for use in a hazard assessment.

Author	ID Number
Hill, et. al.	00034769
Beavers	00150170
Beavers, et. al.	42541801
Beavers, et. al.	42541802

In order to establish the toxicity of linuron to birds, the following tests are required using the technical grade material: two subacute dietary studies (LC_{50}) on one species of waterfowl (preferably the mallard duck) and one species of upland game bird (preferably bobwhite quail or ring-necked pheasant); one avian single-dose oral (LD_{50}) study on one species (preferably mallard or bobwhite quail).

Avian Acute - Technical

The acceptable avian acute oral toxicity study on technical linuron is listed below. The data indicate that linuron is "slightly toxic" on an acute oral basis.

Species	% A.I.	LD_{50}	Author	Date	MRID No.	Classification
Bobwhite Quail	92.8	940 mg/kg	Beavers	1985	00150170	Core[1]

1. Study was upgraded with submission of percent a.i. tested (7/23/90 EEB Review).

Avian Dietary

No acceptable avian dietary toxicity studies on technical linuron have been submitted for review. However, the following data from the USFWS on a 50% formulation were previously considered by EEB to satisfy the requirement (6/24/82 review).

Species	% A.I.	LC_{50}[1]	Author	Date	MRID No.	Classification
Mallard	50	3083 ppm	Hill, et al.	1975	00034769	Supplemental[2]
Japanese Quail	50	>5000 ppm	Hill, et al.	1975	00034769	Supplemental[2,3]
Ring-necked Pheasant	50	3438 ppm	Hill, et al.	1975	00034769	Supplemental[2]

1. Extrapolated by USFWS to 100% ai.
2. Test material is not technical.
3. Not an acceptable test species.

As test material was not technical for the above studies, tests with technical material are required with the mallard and bobwhite quail (71-2 a, b). The USFWS extrapolation suggests that 100% ai material would be considered "slightly toxic" to the mallard and ring-necked pheasant and "practically non-toxic" to the Japanese quail (not an acceptable test species).

Avian Reproduction

Avian reproduction studies are required since birds could be subject to "repeated or continuous exposure" to linuron. Two studies have been submitted and are summarized below.

Species	% ai	Results	Author	Date	MRID	Classification
Mallard	98.4	NOEL = 100 ppm LOEL = 300 ppm[1]	Beavers, et. al.	1992	42541802	Core
Bobwhite quail	98.4	NOEL = 100 ppm LOEL = 300 ppm[2]	Beavers, et. al.	1992	42541801	Core

1. treatment-related effects in adult body weight, feed consumption, egg production, and eggshell thickness
2. treatment-related effects in egg production, hatchability, and offspring survival

Further testing under this guideline (71-4) is not needed at this time.

B. Effects on Freshwater Fish

Six studies in five documents have been previously evaluated by EEB under this topic. All studies were found to be acceptable for use in a hazard assessment.

Author	ID Number
Wetzel	40445501
Wetzel	40354201
Zihal	00018198
Sleight	00018165
Pierson	42061804

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In order to establish the toxicity of linuron to freshwater fish, the minimum data required on the technical grade of the active ingredient are two freshwater fish toxicity studies. One study should use a coldwater species (preferably the rainbow trout) and the other should use a warmwater species (preferably the bluegill sunfish).

Acute Studies - Technical

The acceptable acute fish toxicity studies are listed in the following table:

Species	% A.I.	LC_{50}	Author	Date	MRID No.	Classification
Rainbow trout	96.2	3 ppm	Wetzel	1986	40445501	Core
Bluegill sunfish	96.2	9.6 ppm	Wetzel	1986	40354201	Core

There is sufficient information to characterize technical linuron as "moderately toxic" to both warmwater and coldwater fish. The guideline requirements (72-1 a,b) have been satisfied.

Acute Studies - Formulated Product

Formulated product testing is specified if there is direct application to an aquatic environment or if EECs $\geq$ LC50. In the case of linuron, EECs are not $\geq$ freshwater fish LC50s (see risk assessment). However, linuron is registered for use on Rights-of-Way (ROWs), which can result in a direct application to aquatic environments. Three studies have been previously reviewed.

The acceptable fish toxicity data on the formulated products are listed in the following table:

Species	% A.I.	LC_{50} (product)	Author	Date	MRID No.	Classification
Rainbow trout	50 (WP)	16.4 ppm	Sleight	1973	00018165	Core (for FP)
Bluegill	50 (WP)	16.2 ppm	Sleight	1973	00018165	Core (for FP)
Bluegill	54 (DF)	9.2 ppm	Zihal	1979	00018198	Core (for FP)

These studies indicate that Lorox 50 WP (50% ai) is "slightly toxic" to rainbow trout and bluegill sunfish. Lorox 50 DF (54% ai) is considered "moderately toxic" to bluegill sunfish. No further formulated product testing is needed under this guideline (72-1) at this time.

Chronic Fish Studies

Fish early life stage testing has been previously specified by EEB. The following study has been submitted and previously reviewed by EEB.

Species	% A.I.	Results	Author	Date	MRID No.	Classification
Rainbow trout	98.4	NOEC < 0.042 ppm	Pierson	1991	42061804	Supplemental[1]

1. MATC could not be determined since effects on fish length were seen at the lowest test level.

Additional testing with fish under this guideline is required.

C. Effects on Freshwater Invertebrates

Three studies in three documents have been previously evaluated by EEB under this topic. Both were found acceptable for use in a hazard assessment.

Author	ID Number
Litchfield and Stahl, Jr.	00142932?
Baer	42153401
Goodman	00018199

The minimum testing required to assess the hazard of a pesticide is a freshwater aquatic invertebrate toxicity test, preferably using first instar *Daphnia magna* or early instar amphipods, stoneflies, mayflies, or midges.

Acute Studies - Technical

The acceptable toxicity data are listed in the following table:

Species	% A.I.	EC_{50} (ai)	Author	Date	MRID No.	Classification
Daphnia magna	94.4	0.12 ppm	Litchfield and Stahl, Jr.	1985	00142932?	Core

There is sufficient information to characterize technical linuron as "highly toxic" to aquatic invertebrates. The guideline requirement for an aquatic invertebrate EC_{50} study (72-2a) has been satisfied.

Acute Studies - Formulated Product

Formulated product testing is specified if there is direct application to an aquatic environment or if EECs ≥ LC50. In the case of linuron, EECs ≥ LC50 with runoff to 6" (see risk assessment). The use on ROWs may also result in direct application to water. One study has been previously reviewed.

The acceptable toxicity data on a formulated product are listed in the following table:

Species	% A.I.	LC_{50}	Author	Date	MRID No.	Classification
Daphnia magna	54	1.1 ppm (product)	Goodman	1979	00018199	Core (for FP)

There is sufficient information to characterize this formulation as "moderately toxic" to *D. magna*. No further testing with formulated product under this guideline (72-2) is needed.

Chronic Invertebrate Studies

Invertebrate life-cycle testing has been previously specified and reviewed by EEB. The acceptable toxicity data are listed below.

Species	% A.I.	Results	Author	Date	MRID No.	Classification
Daphnia magna	98.4	MATC > 0.13 < 0.24 ppm	Baer	1991	42153401	Core

These results, however, are inconsistent with acute toxicity data (i.e. 21 day sublethal chronic effects not seen until a level higher than 48-hour EC50). Also, invertebrates were more sensitive than fish in acute tests, but appear considerably less sensitive in the chronic test. Further testing appears necessary to resolve this problem. All available information that would address this inconsistency needs to be provided so that the Agency can determine whether further acute testing, chronic testing, or both are required.

D. Effects on Marine and Estuarine Organisms

Acute Effects - Technical Product

Three studies in three documents were previously received and evaluated by EEB under this topic. All were found to be acceptable for use in a hazard assessment.

Author	ID Number
Ward & Boeri	42061801

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Ward & Boeri 42061802
Ward & Boeri 42061803

Acute toxicity testing with estuarine and marine organisms is required when an end-use product is intended for direct application to the marine/estuarine environment or is expected to reach this environment in significant concentrations. The use of linuron on cotton, corn/sweet corn, forestry, potatoes, sorghum, soybeans, vegetables, and wheat may result in exposure to the estuarine ~~environment through drift and runoff (EEB 4/8/93 Policy memo)~~.

The requirements under this category include a 96-hour LC_{50} for an estuarine fish, a 96-hour LC_{50} for shrimp, and either a 48-hour embryo-larvae study or a 96-hour shell deposition study with oysters.

The acceptable acute estuarine and marine studies are listed in the following table:

Species	% A.I.	LC_{50} (ppm)	Author	Date	MRID No.	Classification
Sheepshead minnow	98.4	0.89	Ward & Boeri	1991	42061801	Core
Eastern Oyster	98.4	5.4	Ward & Boeri	1991	42061802	Core
Mysid shrimp	98.4	3.3	Ward & Boeri	1991	42061803	Core

There is sufficient information to characterize technical linuron as "highly toxic" to the sheepshead minnow, and "moderately toxic" to the eastern oyster and mysid shrimp. The guideline requirement has been satisfied.

Acute Effects- Formulated Product

Marine/estuarine formulated product studies are required due to the ROW use. ROWs could cross virtually any habitat, including marine aquatic habitat such as salt marshes. Data are not currently available. Testing is needed with at least the most sensitive species in acute testing (sheepshead minnow) and at least a dry flowable (DF) formulation. A DF formulation was found to be more toxic than expected based on ai in freshwater testing. Additional species and/or formulations may also be needed.

Chronic Effects

Chronic marine/estuarine testing may be specified under the same conditions as with freshwater species (i.e., 158.145 (b) (5)). In the case of linuron, conditions indicating chronic testing include:

1) LC50 value < 1 mg/l

2) EEC ≥ 0.01 LC50

3) aquatic half-life > 4 days

Sheepshead minnow and mysid shrimp should be tested.

E. Effects on Beneficial Insects

One study was previously evaluated under this topic and found acceptable for use in a hazard assessment.

Author	ID Number
Atkins et al.	00018842

The minimum data required to establish the acute toxicity to honey bees is an acute contact LD_{50} study with the technical material. The submitted test is presented below:

Species	% A.I.	LD_{50}	Author	Date	MRID No.	Fulfills Gdln.
Apis mellifera	not reported	120.86 ug/bee	Atkins et al.	1969	00018842	Yes

This study fulfills the data requirement for acute toxicity testing with honey bees. There is sufficient information to characterize linuron as "relatively nontoxic" to bees.

F. Effects on Nontarget Plants

One valid study in one document was previously evaluated under this topic. It was found to be acceptable for use in a hazard assessment.

Author	ID Number
Douglas & Handley	42086801

Terrestrial Tier 2 plant testing (seed germination, vegetative vigor and seedling emergence) is required for linuron because it is an herbicide registered for use on terrestrial food and nonfood sites and the vapor pressure is ≥ 1.0×10^{-5} mm Hg. It also reportedly has at least some aerial application (e.g., soybeans).

Tier 2 aquatic plant testing is required for linuron as it is an herbicide registered for use on terrestrial food/nonfood sites, has a vapor pressure ≥ 1.0×10^{-5} mm Hg, and a water solubility > 10

ppm. It also reportedly has at least some aerial application (e.g., soybeans). The following species should be tested: *Selenastrum capricornutum*, *Lemna gibba*, *Skeletonema costatum*, *Anabaena flos-aquae*, and a freshwater diatom. Tier 2 aquatic plant testing is automatically required for herbicides which are aerially applied.

The acceptable Tier II aquatic phytotoxicity data on the technical material are listed below:

Species	% AI	EC_{50}	Author	Date	MRID No.	Classification
Selenastrum capricornutum	100	5-Day EC_{50} = 0.067 mg ai/L	Douglas & Handley	1988	42086801	Core

Guideline requirements for aquatic plant testing with linuron have been fulfilled for one of five species only. Guideline requirements for terrestrial plant testing are still outstanding.

2. Disciplinary Review Summation

(See references in above topical discussions, except where noted.)

A. Technical Linuron

1. Toxicity to Birds

Technical linuron is considered "slightly toxic" to bobwhite quail on an acute oral basis, with an LD50 of 940 mg/kg. Technical linuron was not tested in available dietary studies.

2. Toxicity to Freshwater Organisms

Technical linuron is considered "moderately toxic" to the rainbow trout and bluegill sunfish, with LC50s of 3 ppm and 9.6 ppm, respectively. It is considered "highly toxic" to *D. magna*, with an EC50 of 0.12 ppm.

On a chronic basis, technical linuron has a NOEC < 0.042 ppm for rainbow trout. For *D. magna*, it reportedly has an MATC > 0.13 ppm and < 0.24 ppm, but this is inconsistent with acute data.

3. Toxicity to Marine and Estuarine Organisms

Technical linuron is considered "highly toxic" to the sheepshead minnow, with an LC50 of 0.89 ppm. It is considered "moderately toxic" to the eastern oyster and mysid shrimp, with LC50s of 5.4 ppm and 3.3 ppm, respectively.

4. Toxicity to Nontarget Insects

Technical linuron is considered "relatively nontoxic" to bees, with an acute contact LD50 of 120.86 ug/bee.

5. Toxicity to Nontarget Plants

Technical linuron has a 5-day EC50 of 0.067 mg ai/L for the aquatic alga *Selenastrum capricornutum*.

6. Toxicity to Nontarget Mammals

Technical linuron (95% ai) has a lowest acute oral LD50 of 2100 mg/kg (rat). A reproductive NOEL in a 3 generation rat study is listed as 25 ppm. Oncogenic potential was seen in rats and mice (TOX oneliners, 3/30/94).

B. End-Use Formulated Products

1. 50% Formulation

a. Toxicity to Birds

USFWS has tested a 50% linuron formulation. They published results (USFWS Special Scientific Report--Wildlife No. 191) based on extrapolation to 100% ai. On this basis, results suggest that 100% ai material would be considered "slightly toxic" to the mallard and ring-necked pheasant on a dietary basis, with reported extrapolated LC50s of 3083 ppm and 3438 ppm, respectively. It would be considered "practically nontoxic" to the Japanese quail, not a recommended test species.

b. Toxicity to Freshwater Organisms

A 50% formulated product (Lorox 50 WP) is considered "slightly toxic" to rainbow trout and bluegill sunfish, with LC50s of 16.4 ppm and 16.2 ppm, respectively.

2. 54% Formulation

a. Toxicity to Freshwater Organisms

A 54% formulated product is considered "moderately toxic" to the bluegill sunfish and *D. magna*, with LC50s of 9.2 ppm and 1.1 ppm, respectively.

B. Ecological Effects Risk Assessment

1. Use Profile

Linuron is an herbicide used for both pre- and post-emergent control of a variety of annual grasses and broadleaf weeds. It is used on the following food/feed sites: asparagus, carrots, celery, field corn, sweet corn, cottonseed, parsley, parsnips, potatoes, sorghum, soybeans, and drill-planted winter wheat (HED Use Table). Nonfood sites include non-agricultural rights-of-way/fencerows/hedgerows, non-agricultural uncultivated areas/soils, ornamental herbaceous plants, and poplar (forest/shelterbelt) (5/15/92 LUIS report).

Maximum application rates range from 1.5 - 4.0 lb ai/A on the various food/feed crops (HED Use Table). Maximum rates range from 1.5 - 3 lb ai/A for the nonfood sites (5/15/92 LUIS report). Formulation types include wettable powders, water dispersable granules (dry flowable), emulsifiable concentrates, and flowable concentrates. Ground sprays with boom sprayers appear to be a common application method (5/15/92 LUIS report). Aerial application is permitted for at least certain formulations on soybeans (HED Use Table; from SACS, 2/25/94).

Based on the HED Use Table, in most cases the maximum seasonal rate for crops is the same as the maximum single application rate. Thus, any repeat applications could only be at lower rates with the sum not exceeding the maximum individual rate in these cases. There are only three listed cases where the maximum seasonal rate is different, as follows (lb ai/A): carrots (2.0), field corn (3.0, a different label from that with the maximum single rate), soybeans (4.0). Thus, "worst case" (i.e. no degradation) risk quotients for these can be seen in the subsequent risk assessment tables in the rows for these rates.

2. Biological Properties

Linuron's mode of action for target species includes inhibition of photosynthesis (6/29/84 Linuron Guidance Document).

3. Environmental Fate Profile (from EFGWB's Summary of the Environmental Fate Assessment, 2/14/94 draft)

Linuron is considered to have an aerobic soil half-life of 49 days, an anaerobic aquatic half-life of < 21 days, a hydrolytic half-life > 30 days (average approximately 945 days), a photolytic aqueous half-life of > 30 days, and photolytic soil half-life > 15 days. Degradation of parent

linuron is considered to be mainly by microbial action. "Enhanced mobility" of linuron could occur in soils with low organic matter, or with heavy rainfall. Three primary degradates are identified in water. EFGWB does not consider that linuron substantially bioaccumulates in bluegill sunfish: bioconcentration factors (BCF) ranged from approximately 40 to 240 in various tissues and elimination was about 92% complete after 14 days in clean water.

4. Risk Assessment

A. Risk to Terrestrial Fauna

Avian and mammalian organisms may be exposed to linuron through multiple routes, including dietary and dermal. Calculations of estimated environmental residues are based on the work by Hoerger and Kenaga (1972).

Avian Acute Risk

High Risk LOCs are not exceeded at any application rate for a single application. Restricted Use Levels of Concern (LOC) are exceeded on short grass at the 3 and 4 lb ai/A rates. Endangered species LOC are exceeded for all the rates evaluated. Residues on insects would not exceed LOCs (see Table 1 below).

Table 1. Avian Acute Risk Quotient and LOC exceedance (dark shading) for the maximum application rates of linuron by use site. (lowest LC50 = 3083 ppm). See Appendix 1 for calculation details.

Use Site	Application Rate	Substrate (EEC)	Risk Quotient (EEC/LC50)	LOC
Carrots, celery, sweet corn, cottonseed, parsley, parsnips, sorghum; ornamental herbaceous plants	1.5 lbs ai	Short Grass (360)	0.12	High Risk ≥ 0.5 RU ≥ 0.2 ES ≥ 0.1
		Insects (87)	0.03	High Risk ≥ 0.5 RU ≥ 0.2 ES ≥ 0.1
Field corn	1.54 lbs ai	short grass (370)	0.12	High Risk ≥ 0.5 RU ≥ 0.2 ES ≥ 0.1
		Insects (89)	0.03	High Risk ≥ 0.5 RU ≥ 0.2 ES ≥ 0.1
Winter wheat (drill planted)	1.75 lbs ai	short grass (420)	0.14	High Risk ≥ 0.5 RU ≥ 0.2 ES ≥ 0.1
		Insects (101.5)	0.03	High Risk ≥ 0.5 RU ≥ 0.2 ES ≥ 0.1
Potatoes; poplar (forest/ shelterbelt)	2.0 lbs ai	short grass (480)	0.16	High Risk ≥ 0.5 RU ≥ 0.2 ES ≥ 0.1
		Insects (116)	0.04	High Risk ≥ 0.5 RU ≥ 0.2 ES ≥ 0.1
Soybeans; non-ag. ROW/fencerows/ hedgerows/ uncultiv. areas/ soils	3.0 lbs ai	short grass (720)	0.23	High Risk ≥ 0.5 RU ≥ 0.2 ES ≥ 0.1
		Insects (174)	0.06	High Risk ≥ 0.5 RU ≥ 0.2 ES ≥ 0.1
Asparagus	4.0 lbs ai	short grass (960)	0.31	High Risk ≥ 0.5 RU ≥ 0.2 ES ≥ 0.1
		Insects (232)	0.08	High Risk ≥ 0.5 RU ≥ 0.2 ES ≥ 0.1

RU = Restricted Use ES = Endangered Species

Avian Chronic Risk

The avian reproduction NOEL is considered 100 ppm, with effects seen at 300 ppm (see topicals above). Both of these

levels are below those residue levels that could occur on short grass within the treated area at even the lowest of the maximum application rates by crop, from a single application. Given this, as well as the persistence of linuron described by EFGWB, it appears that chronic avian risk is present for all use sites.

Table 2. Avian Chronic Risk Quotient and LOC exceedance (dark shading) for the maximum application rates of linuron by use site. (NOEL = 100 ppm). See Appendix 1 for calculation details.

Use Site	Application Rate	Substrate (EEC)	Risk Quotient (EEC/NOEL)	LOC
Carrots, celery, sweet corn, cottonseed, parsley, parsnips, sorghum; ornamental herbaceous plants	1.5 lbs ai	Short Grass (360)	3.60	Chronic Risk* ≥ 1
		Insects (87)	0.87	Chronic Risk* ≥ 1
Field corn	1.54 lbs ai	short grass (370)	3.70	Chronic Risk* ≥ 1
		Insects (89)	0.89	Chronic Risk* ≥ 1
Winter wheat (drill planted)	1.75 lbs ai	short grass (420)	4.20	Chronic Risk* ≥ 1
		Insects (101.5)	1.02	Chronic Risk* ≥ 1
Potatoes; poplar (forest/ shelterbelt)	2.0 lbs ai	short grass (480)	4.80	Chronic Risk* ≥ 1
		Insects (116)	1.16	Chronic Risk* ≥ 1
Soybeans; non-ag. ROW/fencerows/ hedgerows/ uncultiv. areas/ soils	3.0 lbs ai	short grass (720)	7.20	Chronic Risk* ≥ 1
		Insects (174)	1.74	Chronic Risk* ≥ 1
Asparagus	4.0 lbs ai	short grass (960)	9.60	Chronic Risk* ≥ 1
		Insects (232)	2.32	Chronic Risk* ≥ 1

* "Chronic risk, endangered birds may be affected, restricted use recommended"

In addition to risk from direct application, there can be risk to birds feeding in areas adjacent to treated fields, due to drift, particularly with aerial application. The current EEB estimate is 5% (H. Craven, pers. comm.). This added risk, based on this assumption, does not by itself exceed the LOC

(see Table 3).

Table 3. Avian Chronic Risk Quotient and LOC exceedance (dark shading) -- off-site exposure with soybeans

Use Site	Application Rate	Substrate	Risk Quotient (EEC/NOEL)	LOC
Soybeans	3.0 lbs ai	short grass (36)	0.36	Chronic Risk* ≥ 1
		Insects (8.7)	0.087	Chronic Risk* ≥ 1

* "Chronic risk, endangered birds may be affected, restricted use recommended"

Mammals

Acute Risk

Tables 4 and 5 show LD50s/sq. ft. for the use sites, for two small mammals. LD50s/sq. ft. will vary with the weight of the animal, since LD50s are expressed in mg/kg body weight (i.e., for a given LD50, a smaller animal will require less toxicant to receive a lethal dose). For linuron, all LOCs are exceeded for the small, carnivorous least shrew whereas none are for the much heavier, omnivorous rat.

Table 4. Mammalian Risk Quotient and LOC exceedance for the maximum application rates of linuron by use site. (lowest LD50 = 2100 mg/kg; mammal body weight= 0.005 kg, least shrew). See Appendix 1 for calculation details.

Use Site	Application Rate	mg ai/sq. ft.	LD50/sq. ft.	LOC
Carrots, celery, sweet corn, cottonseed, parsley, parsnips, sorghum; ornamental herbaceous plants	1.5 lbs ai	15.6	1.49	High Risk ≥ 0.5 RU ≥ 0.2 ES ≥ 0.1
Field corn	1.54 lbs ai	16.0	1.52	High Risk ≥ 0.5 RU ≥ 0.2 ES ≥ 0.1
Winter wheat (drill planted)	1.75 lbs ai	18.2	1.7	High Risk ≥ 0.5 RU ≥ 0.2 ES ≥ 0.1
Potatoes; poplar (forest/ shelterbelt)	2.0 lbs ai	20.8	2.0	High Risk ≥ 0.5 RU ≥ 0.2 ES ≥ 0.1
Soybeans; non-ag. ROW/fencerows/ hedgerows/ uncultiv. areas/ soils	3.0 lbs ai	31.2	3.0	High Risk ≥ 0.5 RU ≥ 0.2 ES ≥ 0.1
Asparagus	4.0 lbs ai	41.6	4.0	High Risk ≥ 0.5 RU ≥ 0.2 ES ≥ 0.1

RU = Restricted Use ES = Endangered Species

Table 5. Mammalian Risk Quotient and LOC exceedance for the maximum application rates of linuron by use site. (lowest LD50 = 2100 mg/kg; mammal body weight= 0.3 kg, rat). See Appendix 1 for calculation details.

Use Site	Application Rate	mg ai/sq. ft.	LD50/sq. ft.	LOC
Carrots, celery, sweet corn, cottonseed, parsley, parsnips, sorghum; ornamental herbaceous plants	1.5 lbs ai	15.6	0.02	High Risk ≥ 0.5 RU ≥ 0.2 ES ≥ 0.1
Field corn	1.54 lbs ai	16.0	0.03	High Risk ≥ 0.5 RU ≥ 0.2 ES ≥ 0.1
Winter wheat (drill planted)	1.75 lbs ai	18.2	0.03	High Risk ≥ 0.5 RU ≥ 0.2 ES ≥ 0.1
Potatoes; poplar (forest/ shelterbelt)	2.0 lbs ai	20.8	0.03	High Risk ≥ 0.5 RU ≥ 0.2 ES ≥ 0.1
Soybeans; non-ag. ROW/fencerows/ hedgerows/ uncultiv. areas/ soils	3.0 lbs ai	31.2	0.05	High Risk ≥ 0.5 RU ≥ 0.2 ES ≥ 0.1
Asparagus	4.0 lbs ai	41.6	0.07	High Risk ≥ 0.5 RU ≥ 0.2 ES ≥ 0.1

RU = Restricted Use ES = Endangered Species

Chronic Risk

The lowest NOEL dietary concentration reported on TOX Oneliners is 25 ppm, seen in a 1-year dog feeding study and in a 3-generation reproduction study in rats. Oncogenic effects were reported in both mice and rat studies. For mice, "hepatocellular adenomas were significantly increased in the high dose group [1500 ppm] and reached borderline significance in the low dose group [50 ppm]". For rats, "testicular interstitial cell adenomas increased in 125 and 625 ppm males" (TOX Oneliners printed 3/30/94). Given the persistence of linuron in the field and the effects seen in the lab at concentrations well below those expected after initial application, it appears that chronic effects in wild mammals are likely.

B. Risk to Aquatic Fauna

Acute Risk

Acute risk to aquatic organisms has been estimated by comparing EECs to the lowest available linuron technical LC50 or EC50 for fish and aquatic invertebrates. EECs used were derived from two models, one involving runoff to a 6' pond (A) and the second involving runoff to a 6" water body or wetland (B). The latter is to be used for linuron only for the ROW use (H. Craven, pers. comm.). Table 6 shows that fish restricted use LOCs are exceeded under model B (ROWs). Fish endangered species LOCs are exceeded under model B (ROWs) and also under model A for the 4 lb ai/A rate.

Table 7 shows that the aquatic invertebrate high risk LOC is exceeded with model B (ROWs). Aquatic invertebrate restricted use and endangered species LOCs are exceeded for all sites with both models.

Direct application to aquatic habitat could also potentially occur with a ROW use. Direct application to 6" of water would result in 2202 ppb at a 3 lb ai/A rate. This would produce a risk quotient of 2,474 for fish and 18,350 for aquatic invertebrates, vastly exceeding all LOCs.

Table 6. Fish Risk Quotient and LOC exceedance (dark shading) for the maximum application rates of linuron by use site. (lowest LC50 = 0.89 ppm). See Appendix 1 for calculation details.

Use Site	Application Rate	RQ (EEC/EC50) (model[1])	LOC
Carrots, celery, sweet corn, cottonseed, parsley, parsnips, sorghum; ornamental herbaceous plants	1.5 lbs ai	0.021 (A)	High Risk ≥ 0.5 RU ≥ 0.1 ES ≥ 0.05
Field corn	1.54 lbs ai	0.021 (A)	High Risk ≥ 0.5 RU ≥ 0.1 ES ≥ 0.05
Winter wheat (drill planted)	1.75 lbs ai	0.024 (A)	High Risk ≥ 0.5 RU ≥ 0.1 ES ≥ 0.05
Potatoes; poplar (forest/ shelterbelt)	2.0 lbs ai	0.027 (A)	High Risk ≥ 0.5 RU ≥ 0.1 ES ≥ 0.05
Soybeans; non-ag. ROW/fencerows/ hedgerows/ uncultiv. areas/ soils	3.0 lbs ai	0.041 (A) 0.49 (B) (ROW)	High Risk ≥ 0.5 RU ≥ 0.1 (B) ES ≥ 0.05 (B)
Asparagus	4.0 lbs ai	0.055(A)	High Risk ≥ 0.5 RU ≥ 0.1 ES ≥ 0.05 (A)

RU = Restricted Use ES = Endangered Species

1. model: A =runoff to 6' pond; B = runoff to 6" wetland

Table 7. Aquatic Invertebrate Risk Quotient and LOC exceedance (dark shading) for the maximum application rates of linuron by use site. (lowest EC50 = 0.12 ppm). See Appendix 1 for calculation details.

Use Site	Application Rate	RQ (EEC/EC50) (model[1])	LOC
Carrots, celery, sweet corn, cottonseed, parsley, parsnips, sorghum; ornamental herbaceous plants	1.5 lbs ai	0.15 (A)	High Risk ≥ 0.5 RU ≥ 0.1 (A) ES ≥ 0.05 (A)
Field corn	1.54 lbs ai	0.157 (A)	High Risk ≥ 0.5 RU ≥ 0.1 (A) ES ≥ 0.05 (A)
Winter wheat (drill planted)	1.75 lbs ai	0.178 (A)	High Risk ≥ 0.5 RU ≥ 0.1 (A) ES ≥ 0.05 (A)
Potatoes; poplar (forest/ shelterbelt)	2.0 lbs ai	0.203 (A)	High Risk ≥ 0.5 RU ≥ 0.1 (A) ES ≥ 0.05 (A)
Soybeans; non-ag. ROW/fencerows/ hedgerows/ uncultiv. areas/ soils	3.0 lbs ai	0.305 (A) 3.67 (B) (ROW)	High Risk ≥ 0.5 (B) RU ≥ 0.1 (A,B) ES ≥ 0.05 (A,B)
Asparagus	4.0 lbs ai	0.4 (A)	High Risk ≥ 0.5 RU ≥ 0.1 (A,B) ES ≥ 0.05 (A,B)

RU = Restricted Use ES = Endangered Species

1. model: A = runoff to 6' pond; B = runoff to 6" wetland

Chronic Risk

Chronic aquatic effects cannot be fully assessed at this time. Effects (on fish length) were seen at the lowest concentration (0.042 ppm) with rainbow trout in an early life stage test. The "rough-cut" EECs used for the above tables under model A exceed this effect level at the 4 lb ai/A rate and under model B at the 3 lb ai rate (ROWs). Since the NOEL for this study was some untested level below 0.042 ppm, there would likely be further exceedences of the NOEL and thus the chronic LOC (EEC/NOEL $\geq$ 1).

Although the above comparisons are with "rough-cut" EECs, available environmental fate information from EFGWB (see above) indicates potential persistence in water. There is little or no effect of hydrolysis or photolysis (both half-lives > 30 days). Microbial degradation is described by EFGWB; the anaerobic aquatic half-life is reported as < 21 days. Three degradates of unknown toxicity have been identified by EFGWB. Thus, the toxicity of the combined degradates plus remaining parent linuron is also not known.

The chronic effect level for *D. magna* is reportedly 2X the LC50 seen in a previous acute study, a major incosistency. Also, invertebrates were more sensitive than fish in acute tests, but appear considerably less sensitive in the chronic test. Further testing appears necessary to resolve this problem. All available information that would address this inconsistency needs to be provided so that the Agency can determine whether further acute testing, chronic testing, or both are required.

C. Risk to Beneficial Insects

If linuron were applied when crops or other exposed plants were in flower, bees could be exposed. Corn and cotton are specifically cited in a 1/13/83 EEB policy memo as potentially having honeybee exposure. In addition, ornamentals could clearly result in bee exposure. However, minimal risk is expected as linuron is considered "relatively nontoxic" (LD_{50} = 120.86 ug/bee) to honey bees.

D. Risk to Nontarget Plants

Valid data on the toxicity of linuron to nontarget plants is available for only one of five aquatic plants, and not available at all for the ten required terrestrial species. Exposure of nontarget terrestrial and aquatic plants to

linuron is expected primarily due to runoff from ground applications (all use sites) and from runoff and drift for aerial applications (certain soybean labels, as per HED Use Table).

No terrestrial plant risk assessment can be done due to the lack of adequate data. High risk is likely, based on the herbicidal properties of linuron.

Only a preliminary aquatic plant risk assessment can be done since adequate data are available for just one of five species. High risk and endangered plant LOCs are exceeded for aquatic plants if the EEC/EC50 $\geq$ 1. Based on the EECs previously calculated to evaluate risk to aquatic animals, and the one available EC50 (0.067 ppm), these LOCs are exceeded under the runoff to wetland model (6") for ROWs, but not the runoff to 6' pond model for all other uses.

4. **Endangered Species**

As described in the above risk assessment sections, endangered species LOCs are exceeded in some instances for acute effects to birds, wild mammals, aquatic organisms and nontarget plants. Endangered species LOCs are exceeded for chronic effects to birds, wild mammals, and aquatic organisms.

The Endangered Species Protection Program is expected to become final in 1994. Limitations on the use of linuron will be required to protect endangered and threatened species, but these limitations have not yet been defined (and may be formulation specific). OPP anticipates that consultation with the Fish and Wildlife Service will be conducted in accordance with the species-based priority approach described in the Program. After completion of consultation, registrants will be informed if any required label modifications are necessary. Such modifications would most likely consist of the generic label statement referring pesticide users to use limitations contained in county Bulletins.

C. **Labelling**

1. Manufacturing-Use

Do not discharge effluent containing this product into lakes, streams, ponds, estuaries, oceans or other waters unless in accordance with the requirements of a National Pollutant Discharge Elimination System (NPDES) permit and the permitting authority has been notified in writing prior to discharge. Do not discharge effluent containing this product to sewer systems without previously notifying the local sewage treatment plant authority. For guidance contact your State Water Board or Regional

Office of the EPA.

2. End-Use (H. Craven, pers. comm.)

a) terrestrial crop and noncrop uses except rights-of-way

This pesticide is toxic to fish and aquatic invertebrates. Do not apply to water, or to areas where surface water is present or to intertidal areas below the mean high water mark. Do not contaminate water when disposing of equipment washwaters or rinsate.

b) rights-of-way

This pesticide is toxic to fish and aquatic invertebrates. Do not contaminate water when disposing of equipment washwaters or rinsate.

D. **Data Requirements** (See attached data table)

Outstanding Data Requirements

1) **72-4 (a) Fish early life-stage** (rainbow trout)

2) **123-1 (a) Seed Germination/Seedling Emergence** - 10 species.

3) **123-1 (b) Vegetative Vigor** - 10 species.

4) **123-2 Aquatic plant growth** - 4 additional species.

New Data Requirements

1) **71-2 (a, b) - Avian dietary LC50 (technical)** - 2 species

2) **72-2(a) Aquatic invertebrate LC50 (TGAI) and/or 72-4 (b) - Life-Cycle Aquatic Invertebrate** with *Daphnia magna* [NOEL and LOEL consistent with acute testing needed (see text)].

3) **72-3 (d, e, f) - Acute marine/estuarine testing with TEP(s)**

4) **72-4 (a) - Fish early life stage** (sheepshead minnow).

5) **72-4 (b) - Invertebrate life-cycle** (mysid shrimp).

E. Value Added Analysis re Data Requirements

1) Acute Data

At present, EEB is using avian LC50 values extrapolated by USFWS to 100% active ingredient from a 50% ai formulation. With submission of core studies on technical material, this would not be necessary. Some toxicity in formulation testing may be due to ingredients other than the active ingredient. Other formulations may be more or less toxic, depending on their ingredients. Technical testing allows prediction of the toxicity due to the ai across all formulations.

At present, EEB is using marine/estuarine testing with technical material for risk assessment. Because of the ROW use, there could be direct exposure of the aquatic environment with the formulated product. Thus, TEP testing will enable EEB to assess the risk of specific formulation(s) actually used on ROWs. The sheepshead minnow was the most sensitive test species in the TGAI testing. Four formulation types are used on ROW (EC, FC, DF, WP) according to the 5/15/92 LUIS report. A 54% ai DF formulation was previously found to be roughly twice as toxic to the bluegill as might be predicted based on ai alone.

At present, EEB has valid test data on only one of five required aquatic plant species and none of the ten required terrestrial plant species. As an herbicide, EEB assumes linuron is toxic to plants. However, a plant risk assessment cannot be performed without the phytotoxicity data.

2) Chronic data

At present, EEB does not know at what level linuron will not have adverse effects on fish, since a NOEL was not determined in fish testing. Submission of a core study will enable us to determine this level, and thus determine what maximum application rate of linuron could be used without producing residues capable of causing the kinds of chronic effects evaluated under current test protocols.

At present, EEB has chronic invertebrate data that appear inconsistent with acute data: chronic effects were not seen until levels higher than those causing acute effects. Also, invertebrates were more sensitive than fish in acute tests, but appear considerably less sensitive in the chronic test. Any available information that would help explain this inconsistency will help EEB determine whether a new chronic study, a new acute study, or both will be needed.

At present EEB has no chronic marine/estuarine data with which to conduct a risk assessment. Due to the use patterns and

environmental fate characteristics of linuron, marine estuarine exposure can be expected from use on cotton, corn/sweet corn, forestry, soybeans, vegetables, and wheat (3/8/93 EEB policy memo). Conditions indicating chronic testing include: 1) LC50 value < 1 mg/l; 2) EEC $\geq$ 0.01 LC50; 3) aquatic half-life > 4 days. Freshwater fish were substantially more sensitive chronically than acutely. Since the marine/estuarine fish was more sensitive than the freshwater fish in acute tests, it may well be the most sensitive chronically as well. Sheepshead minnow and mysid shrimp should be tested.

The "value added" of all the above data is considered "high" by EEB, except for the avian LC50 with TGAI, which is considered "low" (H. Craven, pers. comm.).

F. Proposed Risk Mitigation Measures

1) Reduce Maximum Application Rate. A maximum application rate of 0.1 lb ai/A, with use limited to a single application, would appear to get below currently known LOCs based on available acute and chronic data (e.g., not including fish chronic endpoint where a NOEL not available). As noted above, a variety of additional data, including additional plant studies and chronic aquatic studies, are required to complete a risk assessment.

2) Prohibit aerial application. Available information indicates that aerial application to soybeans is permitted by certain labels. Prohibiting this practice would reduce the potential for drift to nontarget plants and water bodies. EEB would still need the above data to assess effects.

CITATIONS

Hoerger, F.D. and E.E. Kenaga. 1972. Pesticide residues on plants correlation of representative data as a basis for estimation of their magnitude in the environment. Environmental Quality, Acadmic Press, New York, I: 9-28.

APPENDIX 1

Table 1 Calculations

EEC for short grass = Application rate (lb ai/A) X 240 ppm/lb ai
EEC for insects = " " X 58 "
(based on Hoerger and Kenaga, 1972)

lowest avian LC50 = 3083 ppm (mallard duck)

Risk Quotient = EEC/LC50

Table 2 Calculations

Table uses same EECs as Table 1.

Risk Quotient = EEC/NOEL

Table 3 Calculations

EEB Off-site Drift estimate = 5% of EEC (from Table 1)

Table 4 and 5 Calculations

mg ai/sq. ft. = lb ai/A X 10.4 (conversion factor)

animal weight = 0.005 kg (least shrew)
= 0.3 kg (rat)

lowest mammal LD50 = 2100 mg/kg (rat)

$$\text{Risk quotient} = \text{LD50/sq. ft.} = \frac{\text{mg ai/sq. ft.}}{\text{LD50 X animal weight}}$$

Table 6 and 7 calculations

(see EEB 12/6/85 SOP)

EEC for model A (runoff to 6' pond) =

[Applic. rate (lb ai/A) X % runoff X 10A drainage basin]
X 61 ppb/lb ai

where % runoff = 2% (based on linuron water solubility of 81 ppm)

EEC for model B (runoff to 6" wetland) =

[Applic. rate (lb ai/A) X % runoff X 10A drainage basin]
X 734 ppb/lb ai

with same % runoff

Risk quotient = EEC/LC50
where lowest fish LC50 = 0.89 ppm (sheepshead minnow)
and lowest aquatic invertebrate EC50 = 0.12 ppm (*D. magna*)

Date: 5/4/94
Case No: 0047
Chemical No: 035506

PHASE IV
DATA REQUIREMENTS FOR LINURON
ECOLOGICAL EFFECTS BRANCH

Data Requirements	Composition [1]	Use Pattern [2]	Does EPA Have Data To Satisfy This Requirement? (Yes, No)	Bibliographic Citation	Must Additional Data Be Submitted under FIFRA3(c)(2)(B)?
6 Basic Studies in Bold					
71-1(a) Acute Avian Oral, Quail/Duck	TGAI	A,C,E,J,K	yes	MRID 00150170	no
71-1(b) Acute Avian Oral, Quail/Duck	(TEP)				
71-2(a) Acute Avian Diet, Quail	TGAI	A,C,E,J,K	partially	MRID 00034769	yes [3]
71-2(b) Acute Avian Diet, Duck	TGAI	A,C,E,J,K	partially	MRID 00034769	yes [3]
71-3 Wild Mammal Toxicity					
71-4(a) Avian Reproduction Quail	TGAI	A,C,E,J,K	yes	MRID 42541801	no
71-4(b) Avian Reproduction Duck	TGAI	A,C,E,J,K	yes	MRID 42541802	no
71-5(a) Simulated Terrestrial Field Study					
71-5(b) Actual Terrestrial Field Study					
72-1(a) Acute Fish Toxicity Bluegill	TGAI	A,C,E,J,K	yes	MRID 40354201	no
72-1(b) Acute Fish Toxicity Bluegill	(TEP)	A,C,E,J,K	yes	MRID 00018165 MRID 00018198	no
72-1(c) Acute Fish Toxicity Rainbow Trout	TGAI	A,C,E,J,K	yes	MRID 40445501	no
72-1(d) Acute Fish Toxicity Rainbow Trout	(TEP)	A,C,E,J,K	yes	MRID 00018165	no
72-2(a) Acute Aquatic Invertebrate Toxicity	TGAI	A,C,E,J,K	yes	MRID 00142932?	yes [4]
72-2(b) Acute Aquatic Invertebrate Toxicity	(TEP)	A,C,E,J,K	yes	MRID 00018199	no
72-3(a) Acute Estu/Mari Tox Fish	TGAI	A,C,E,J,K	yes	MRID 42061801	no
72-3(b) Acute Estu/Mari Tox Mollusk	TGAI	A,C,E,J,K	yes	MRID 42061802	no
72-3(c) Acute Estu.Mari Tox Shrimp	TGAI	A,C,E,J,K	yes	MRID 42061803	no

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* In Bibliographic Citation column indicates study may be upgradeable

Date: 5/4/94
Case No: 0047
Chemical No: 035506

PHASE IV
DATA REQUIREMENTS FOR LINURON
ECOLOGICAL EFFECTS BRANCH

Data Requirements	Composition [1]	Use Pattern [2]	Does EPA Have Data To Satisfy This Requirement? (Yes, No)	Bibliographic Citation	Must Additional Data Be Submitted under FIFRA3(c)(2)(B)?
72-3(d) Acute Estu/Mari Tox Fish	(TEP)	A,C,E,J,K	no		yes [5]
72-3(e) Acute Estu/Mari Tox Mollusk	(TEP)	A,C,E,J,K	no		yes [5]
72-3(f) Acute Estu/Mari Tox Shrimp	(TEP)	A,C,E,J,K	no		yes [5]
72-4(a) Early Life-Stage Fish	TGAI	A,C,E,J,K	partially	MRID 42061804	yes [6]
72-4(b) Life-Cycle Aquatic Invertebrate	TGAI	A,C,E,J,K	partially	MRID 42153401	yes [7]
72-5 Life-Cycle Fish	TGAI	A,C,E,J,K	no		reserved [8]
72-6 Aquatic Org. Accumulation					
72-7(a) Simulated Aquatic Field Study					
72-7(b) Actual Aquatic Field Study					
122-1(a) Seed Germ./Seedling Emerg.	TGAI				
122-1(b) Vegetative Vigor	TGAI				
122-2 Aquatic Plant Growth	TGAI				
123-1(a) Seed Germ./Seedling Emerg.	TGAI	A,C,E,J,K	no		yes [9]
123-1(b) Vegetative Vigor	TGAI	A,C,E,J,K	no		yes [9]
123-2 Aquatic Plant Growth	TGAI	A,C,E,J,K	yes	MRID 42086801	yes [10]
124-1 Terrestrial Field Study					
124-2 Aquatic Field Study					
141-1 Honey Bee Acute Contact	TGAI	A,C,E,J,K	yes	MRID 00018842	no
141-2 Honey Bee Residue on Foliage					
141-5 Field Test for Pollinators					

W

* In Bibliographic Citation column indicates study may be upgradeable

1.Composition: TGAI=Technicalgrade of the active ingredient; PAIRA=Pureactive ingredient, radiolabeled; TEP=Typicalend-use product

2.Use Patterns: A=TerrestrialFood Crop; B=TerrestrialFeed Crop; C=TerrestrialNon-Food Crop; D=AquaticFood Crop; E=Aquatic Non-Food Outdoor; F=Aquatic Non-Food Industrial; G=Aquatic Non-Food Residential; H=Greenhouse Food Crop; I=Greenhouse Non-Food Crop; J=Forestry; K=Outdoor Residential; L=IndoorFood; M=IndoorNon-Food; N=IndoorMedical; O=Indoor Residential; Z=UseGroup for Site 00000

3. Testing with TGAI required.

4. A D. magna NOEL and LOEL consistent with acute toxicity testing is required.

5. Testing with TEP(s) required to support the rights-of-way (ROW) use. At a minimum, testing will be required with the sheepshead minnow (most sensitive species in acute testing) and a dry flowable (DF) formulation (shown in other testing to be more toxic than expected based on % ai). Additional species and/or formulations may also be required.

6. a) A NOEL with rainbow trout is required.

b) A chronic sheepshead minnow study is required to support the use of linuron on cotton, corn/sweet corn, forestry, potatoes, sorghum, soybeans, vegetables, and wheat.

7. a) A D. magna NOEL and LOEL consistent with acute toxicity testing is required.

b) A chronic mysid shrimp study is required to support the use of linuron on cotton, corn/sweet corn, forestry, potatoes, sorghum, soybeans, vegetables, and wheat.

8. This study is reserved, pending results of fish early life stage and aquatic invertebrate life-cycle tests.

9. Testing with ten species is required.

10. Testing with the remaining four species is required.